FORM-PTO-1390 REV. 5-93 **TRANSMITTAL LETTER TO THE UNITED STATES** **DESIGNATED/ELECTED OFFICE (DO/EO/US)** **CONCERNING A FILING UNDER 35 U.S.C. 371**	US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEYS DOCKET NUMBER P01,0052
		U.S.APPLICATION NO. (if known, see 37 CFR 1.5) *09/787997*

INTERNATIONAL APPLICATION NO. **PCT/DE99/01993**	INTERNATIONAL FILING DATE **01 July 1999**	PRIORITY DATE CLAIMED **24 September 1998**

TITLE OF INVENTION

METHOD FOR CODING, DECODING AND TRANSMITTING INFORMATION
SIGNAL PROCESSOR AND RADIO EQUIPMENT

APPLICANT(S) FOR DO/EO/US

NORBERT LOEBIG

pplicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒   This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐   This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐   This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒   A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒   A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached.
      a. ☒   is transmitted herewith (required only if not transmitted by the International Bureau).
      b. ☐   has been transmitted by the International Bureau.
      ☐   is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒   A translation of the International Application into English (35 U.S.C. 371(c)(2) - drawings attached.

7. ☐   Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
      a. ☐   are transmitted herewith (required only if not transmitted by the International Bureau).
      b. ☐   have been transmitted by the International Bureau.
      c. ☐   have not been made; however, the time limit for making such amendments has NOT expired.
      d. ☐   have not been made and will not be made.

8. ☐   A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒   An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐   A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:
11. ☒   An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report).**

12. ☒   An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. (Separate envelope)

13. ☒   A FIRST preliminary amendment.
      ☐   A SECOND or SUBSEQUENT preliminary amendment.

14. ☒   A substitute specification, including red-lined version

15. ☒   A change of power of attorney and/or address letter.

16. ☒   Other items or information:
      a. ☒   Submission of Ready to publish drawings
      b. ☒   Request for Approval of Drawing Changes
      c. ☒   Express Mail Label EJ 778078625US

U.S.APPLICATION NO. (if known, see 37 C.F.R. 1.5) 09/787997	INTERNATIONAL APPLICATION NO. PCT/DE99/01993	ATTORNEY'S DOCKET NUMBER P01,0052

	CALCULATIONS	PTO USE ONLY
17. ☒ The following fees are submitted: **BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):** Search Report has been prepared by the EPO or JPO .... $860.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482)$690.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) .... $760.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO .... $1000.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		

ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	

Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).	$	

Claims	Number Filed		Number Extra	Rate		
Total Claims	12	- 20 =		X $18.00	$	
Independent Claims	2	- 3 =		X $ 80.00	$	
Multiple Dependent Claims				$270.00 +	$	

TOTAL OF ABOVE CALCULATIONS =	$860.00	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)	$	
SUBTOTAL =	$860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$	
TOTAL NATIONAL FEE =	$860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +		
TOTAL FEES ENCLOSED =	$860.00	

	Amount to be refunded	$
	charged	$

a. ☒ A check in the amount of $860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 501519 . A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Schiff Hardin & Waite
Patent Department
6600 Sears Tower
Chicago, Illinois 60606
Customer No. 26574
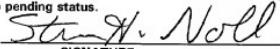
Steven H. Noll
SIGNATURE

Steven H. Noll
NAME

28,982   (Registration No.)

BOX PCT

IN THE UNITED STATES DESIGNATED OFFICE

OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER THE PATENT COOPERATION TREATY-CHAPTER II

5   **AMENDMENT "A" PRIOR TO ACTION AND SUBMISSION OF**

SUBSTITUTE SPECIFICATION

APPLICANT: Wen Xu

ATTORNEY DOCKET NO.   P01,0052

INTERNATIONAL APPLICATION NO: PCT/DE99/01993

10   INTERNATIONAL FILING DATE: July 1, 1999

INVENTION: "METHOD   FOR   CODING,   DECODING   AND

TRANSMITTING   INFORMATION,   SIGNAL

PROCESSOR AND RADIO EQUIPMENT"

Assistant Commissioner for Patents

15   Washington, D.C. 20231

Sir:

Applicant herewith amends the above-referenced PCT application as

follows, and requests entry of the Amendment prior to examination in the

United States National Examination Phase.

20   **IN THE SPECIFICATION:**

Applicant herewith submits a substitute specification pursuant to 37

C.F.R. §1.125(b). The substitute specification does not contain any new

matter. A marked up copy of the substitute specification, showing all of the

changes made therein, is also submitted herewith.

25   **IN THE DRAWINGS:**

Please amend each of Figures 1, 2 and 3 as shown on the drawing

copies marked in red attached to the Request for Approval of Drawing

Changes, filed simultaneously herewith.

-2-

IN THE CLAIMS:

On page 15, cancel "Patent claims" and substitute

--**I CLAIM AS MY INVENTION:**-- therefor.

Please cancel claims 1-10 and substitute the following claims therefor:

11.   A method for coding information consisting of symbol sequences containing symbols which occur with different probabilities, comprising the steps of:

mapping said symbols to binary code words, each having a plurality of bit positions; and

in said mapping, sorting said symbols dependent on their respective probability of occurrence, and allocating a natural code words to said symbols to obtain sorted symbols, and allocating a natural binary code to said sorted symbols.

12.   A method as claimed in claim 11 wherein the step of sorting said symbols comprises sorting a substantial proportion of said symbols, thereby obtaining a substantial proportion of sorted symbols, and comprising allocating said natural binary code to said substantial proportion of sorted symbols.

13.   A method as claimed in claim 11 wherein the step of sorting said symbols comprises sorting all of said symbols, and allocating said natural binary code to all of said sorted symbols.

14.   A method as claimed in claim 11 wherein the step of allocating said natural binary code comprises:

allocating a code word which exhibits a first binary value at all bit positions to a symbol which occurs most frequently; and

allocating a code word which exhibits a second binary value at all positions to a symbol occurring most infrequently.

15.   A method as claimed in claim 11 comprising producing said symbol sequences from a source encoding.

16.   A method as claimed in claim 11 comprising interchanging bit positions of code words obtained from said mapping.

17.   A method as claimed in claim 11 wherein said symbol sequences contain redundant information, and comprising decoding said natural binary code using said redundant information as a priori information for determining respective values of said bit positions.

18.   A method as claimed in claim 11 wherein said symbol sequences contain redundant information, and comprising decoding said natural binary code using said redundant information as a posteriori information for determining respective values of said bit positions.

19.   A method as claimed in claim 11 wherein said bit positions of said code words contain redundant information, and comprising decoding said natural binary code using said redundant information as a priori information for determining respective values of said bit positions.

20.   A method as claimed in claim 11 wherein said bit positions of said code words contain redundant information, and comprising decoding said natural binary code using said redundant information as a posteriori information for determining respective values of said bit positions.

21.   A signal processing arrangement for coding information consisting of symbol sequences containing symbols which occur with different probabilities, comprising the steps of:

mapping said symbols to binary code words, each having a plurality of bit positions; and

in said mapping, sorting said symbols dependent on their respective probability of occurrence, and allocating a natural code words to said symbols to obtain sorted symbols, and allocating a natural binary code to said sorted symbols.

22.   A signal processing arrangement as claimed in claim 21 wherein said symbol sequences contain redundant information, and comprising decoding said natural binary code using said redundant information as a priori information for determining respective values of said bit positions.

IN THE ABSTRACT:

Please cancel the present Abstract and substitute the Abstract attached hereto on separately numbered page 17.

REMARKS:

The present Amendment makes editorial changes in the specification, claims, drawings, and Abstract to conform to the requirements of United States patent practice. All changes in the claim language have been made solely for the purpose of bringing the claims into compliance with the requirements of 35 U.S.C. §112, second paragraph, and no change in any of the claims has been made for the purpose of distinguishing any of the claims over the teachings of the prior art of record. Accordingly, no change

in any of the claims is considered by the Applicant as a surrender of any the subject matter encompassed within the scope of the claims as originally filed.

Submitted by,

Stu N. Noll   (Reg. 28,982)

SCHIFF, HARDIN & WAITE
CUSTOMER NO. 26574
Patent Department
6600 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606
Telephone: 312/258-5790
Attorneys for Applicant.

ABSTRACT OF THE DISCLOSURE

In a method, and a signal processing arrangement, for coding information, the information symbol sequences are first sorted in accordance with the probability of occurrence of the symbols in the sequences, and are then mapped to the natural binary code. This allows redundant information contained in the symbol sequences to be used for decoding the bit positions.

BOX PCT

IN THE UNITED STATES DESIGNATED OFFICE

OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER THE PATENT COOPERATION TREATY-CHAPTER II

5   **REQUEST FOR APPROVAL OF DRAWING CHANGES**

APPLICANT: Wen Xu

ATTORNEY DOCKET NO.   P01,0052

INTERNATIONAL APPLICATION NO: PCT/DE99/01993

INTERNATIONAL FILING DATE: July 1, 1999

10   INVENTION: "METHOD   FOR   CODING,   DECODING   AND

TRANSMITTING   INFORMATION,   SIGNAL

PROCESSOR AND RADIO EQUIPMENT"

Assistant Commissioner for Patents,

Washington, D.C.

15   S I R:

Applicant herewith requests approval of the drawing changes in each

of Figures 1, 2 and 3, as shown on the drawing copies marked in red

attached hereto.

Submitted by,

20   _____   (Reg. 28,982)

SCHIFF, HARDIN & WAITE

CUSTOMER NO. 26574

Patent Department

6600 Sears Tower

25   233 South Wacker Drive

Chicago, Illinois 60606

Telephone: 312/258-5790

Attorneys for Applicant.

FIG.1

FIG. 2

BM

SY $\longrightarrow$ BCW

$c_j \longrightarrow$ bcw,j

$...b_{j,i-1}\ b_{j,i}\ b_{j,i+1}...$ $b \in 0,1$

$u_{k-1,q-1}\ u_{k-1,q}$ ... $u_{k-1,q+1}$ ... | $u_{k,q-1}\ u_{k,q}\ u_{k,q+1}$ ...

Frame k-1   Frame k
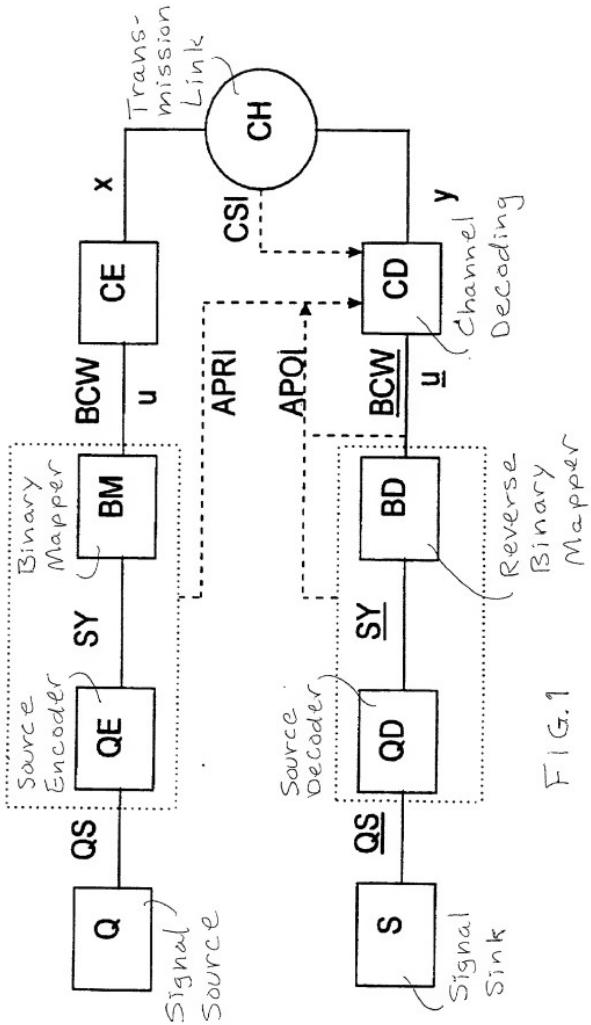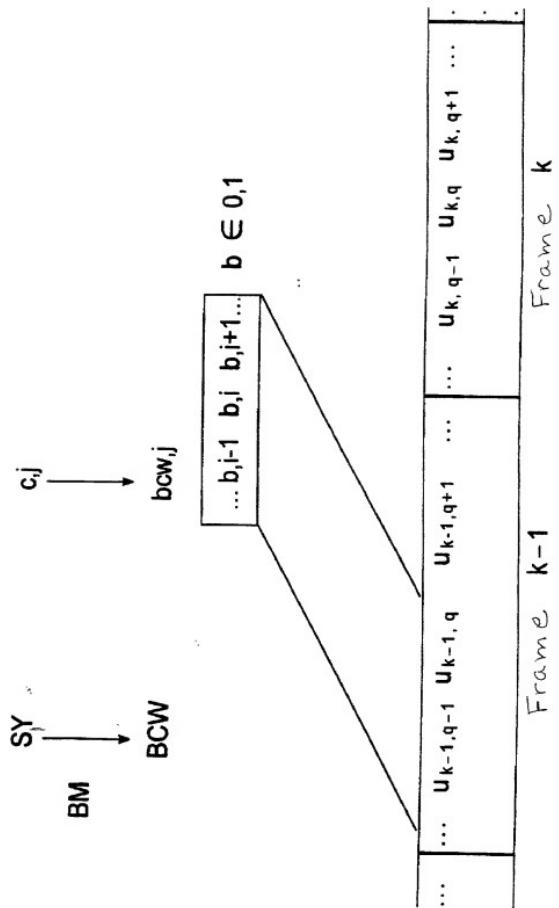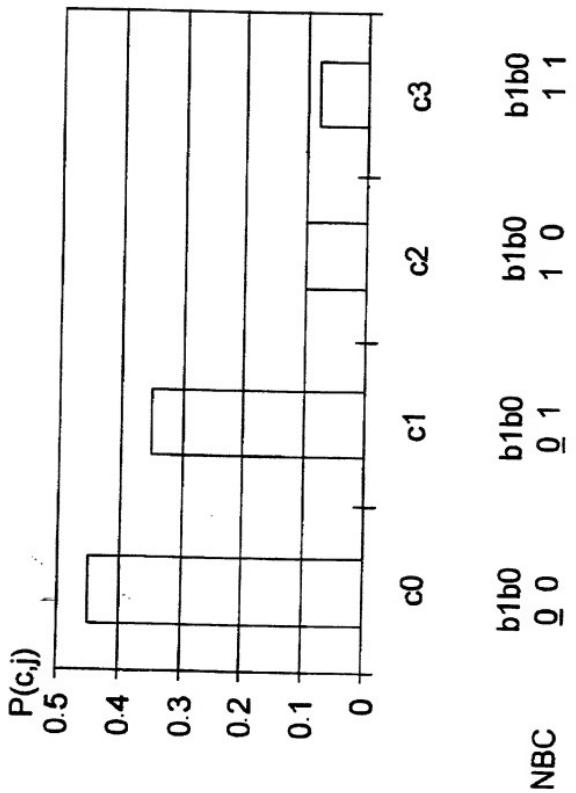
FIG. 3

BOX PCT

IN THE UNITED STATES DESIGNATED OFFICE

OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER THE PATENT COOPERATION TREATY-CHAPTER II

5   **SUBMISSION OF READY TO PUBLISH DRAWINGS**

APPLICANT: Wen Xu

ATTORNEY DOCKET NO.   P01,0052

INTERNATIONAL APPLICATION NO: PCT/DE99/01993

INTERNATIONAL FILING DATE: July 1, 1999

10   INVENTION: "METHOD   FOR   CODING,   DECODING   AND
                        TRANSMITTING   INFORMATION,   SIGNAL
                        PROCESSOR AND RADIO EQUIPMENT"

Assistant Commissioner for Patents,

        Washington, D.C. 20231

15   S I R:

        Applicant herewith submits three sheets (Figs. 1-3) of "ready to

publish" drawings for the above-referenced PCT application.

                        Submitted by,

20   _____ (Reg. 28,982)
                        SCHIFF, HARDIN & WAITE
                        CUSTOMER NO. 26574
                        Patent Department
                        6600 Sears Tower
                        233 South Wacker Drive
25   Chicago, Illinois 60606
                        Telephone: 312/258-5790
   Attorneys for Applicant.

FIG.1

FIG. 2

FIG. 3
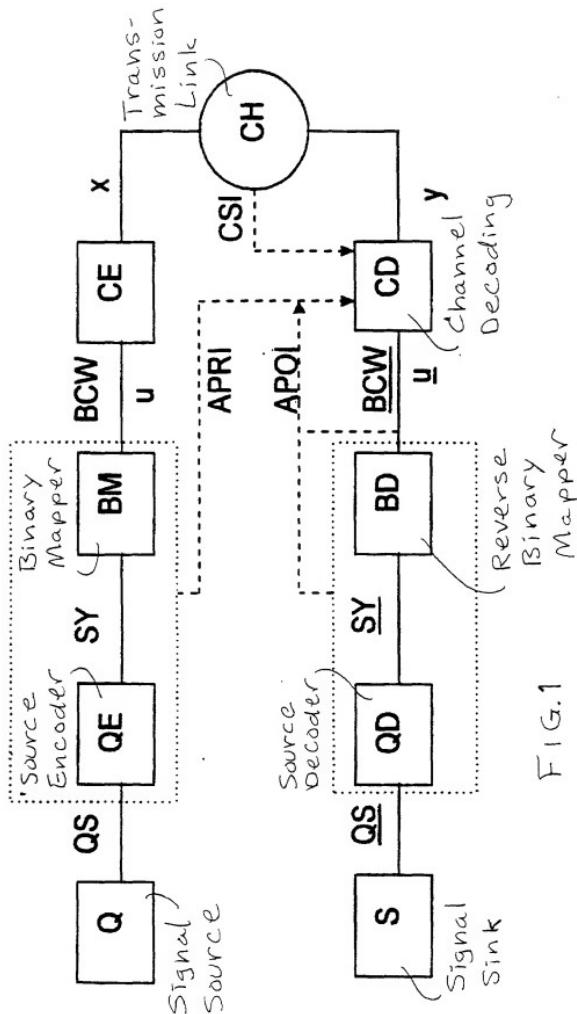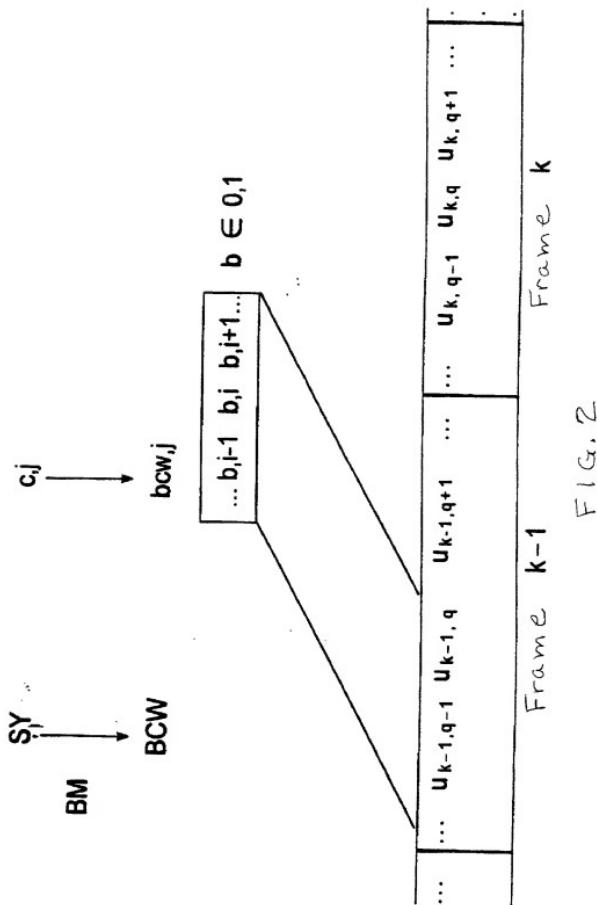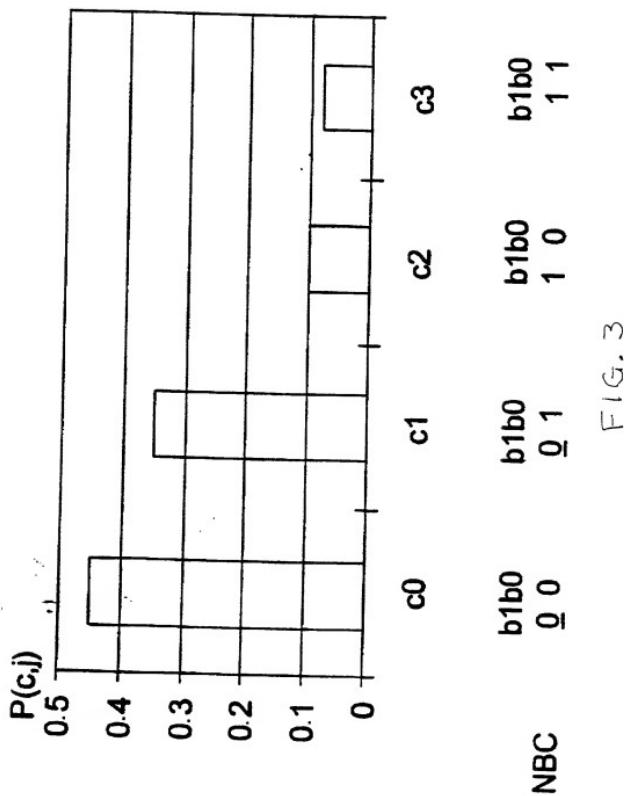
S P E C I F I C A T I O N

TITLE

"METHOD FOR CODING, DECODING AND TRANSMITTING
INFORMATION, SIGNAL PROCESSOR AND RADIO EQUIPMENT"

5 ### BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method for coding
and decoding information, especially for digital
transmission or storage.

10 ### Description of the Prior Art

Source signals or source information such as voice,
sound, image and video signals almost always contain
statistical redundancy, that is to say redundant
information. This redundancy can be greatly reduced by
15 source encoding, making it possible to transmit and/or
store the source signal efficiently. This redundancy
reduction eliminates redundant signal contents which are
based on the prior knowledge of, for example, statistical
parameters of the signal variation, before the
20 transmission. After the transmission, these components
are added to the signal again in the source decoding, so
that no loss of quality can be detected objectively.

Due to the incomplete knowledge of the source
signals or restrictions in the complexity of the source
25 encoding method, the source encoding usually only can be
implemented in a suboptimum way, that is to say the
compressed data still contain a certain redundancy even
after the source encoding. In previous methods for source
encoding, the source signals are frequently compressed
30 to form symbols or quantized parameters which are then
mapped to binary code words in accordance with an

allocation rule, the allocation rule having been selected more or less randomly until now.

On the other hand, it is usual to deliberately add redundancy again by channel encoding during the signal transmission in order to largely eliminate the effect of co-channel interference on the transmission. Additional redundant bits thus enable the receiver or, respectively, decoder to detect and possibly also to correct errors.

It has long been one of the basic premises of information theory that source encoding and channel encoding can be carried out independently of one another in order to achieve an optimum result. According to this principle, the design of the source decoder depends only on the source characteristics whereas the channel encoding arrangement should depend only on the channel characteristics. This principle can be correct if the source encoder delivers statistically independent and thus uncorrelated symbols of equal probability and the decoding delay can be of any magnitude. In practical applications, however, these prerequisites are not met, as a rule. The output signal of the source encoder or, respectively, the symbol sequences output by it frequently exhibit a residual redundancy and, at the same time, the permissible delay is restricted, especially in voice transmission.

It is known to utilize this residual redundancy of the source-encoded symbol sequences in the so-called source-controlled channel decoding. In this process, the decoding process of the channel decoder is controlled, on the one hand, by the transmitted bits and, on the other hand, by a priori/a posteriori information on the

most probable value of some important source bits. The source information thus has an influence on the result of the channel decoding. In the case of the Viterbi algorithm decoding, this method is called an a priori

5   Viterbi algorithm. When such a method is used, only the receiver needs to be modified. Thus, the printed document J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pages 2449-2457, September 1995, teaches to use the inter-frame correlation, that is to

10 say the statistical dependence between temporally and/or spatially adjacent signal samples in the source-controlled channel decoding.

Investigations have also shown that there is residual redundancy not only between bits of successive

15 frames but also between the bits of a parameter within a frame due to the uneven distribution of the parameter values which, in turn, is attributable to the non-stationary condition of the source signals.

SUMMARY OF THE INVENTION

20 The present invention has the object of achieving information transmission or information storage with the fewest possible errors and the least possible expenditure.

According to the invention, the abovementioned

25 object is achieved.

First sorting the symbols in accordance with their relative frequency and allocating the natural binary code to the sorting result.

The invention has the result that the error rate of

30 the decoded bits can be reduced without additional

expenditure, and thus information can be transmitted with fewer disturbances.

In the text which follows, the invention will be described in greater detail with reference to preferred illustrative embodiments. In this connection, it is especially the digital transmission of the information which is described. Nevertheless, the information can also be applied to the storage of information since the writing of information to a storage medium and the reading of information from a storage medium correspond to the sending of information and the receiving of information with regard to the present invention.

The term "decoding" is frequently used for describing the decoding of channel-encoded bit positions whilst the term "detection" is used if generally the binary values of a bit position are decided. Since the present invention is advantageously applicable to both cases, the term "decoding" also contains the process of detection within the context of the present patent application.

Description of the Drawings

Figure 1 is a schematic representation of a communication chain constructed and operated in accordance with the invention.

Figure 2 is a diagram showing the relationship between symbols and the source-encoded bit sequences in a frame structure, in accordance with the invention.

Figure 3 illustrates the frequency distribution of the symbols and the binary values dependent on binary mapping, in accordance with the invention.

Description of the Preferred Embodiments

Figure 1 shows a source Q which generates source signals QS which are compressed into symbol sequences SY consisting of symbols by a source encoder QE like the GSM full-rate voice encoder. Here, the symbols have one of the values c,j (symbol value). In parametric source encoding methods, the source signals QS (e.g. voice) generated by the source Q are subdivided into blocks (e.g. time frames) and these are processed separately. The source encoder QE generates quantized parameters (e.g. voice coefficients) which are also called symbols of a symbol sequence SY in the text which follows and which reflect the characteristics of the source in the current block in a certain manner (e.g. spectrum of the voice, filter parameter). These symbols have a certain symbol value c,j after the quantization.

Thus, for example, the GSM full-rate encoder generates 76 parameters, of which parameters 0 to 7 are the so-called LAR (logarithmic area ratio) coefficients which are generated during the LPC (linear prediction coding) analysis. Parameters 9, 26, 43 and 60 are similarity values for the so-called LTP (long-term prediction). Each frame also contains four XMAX coefficients (or parameters) from the so-called RPE (residual pulse excitation) analysis which change only little from frame to frame.

Due to the incomplete knowledge of the source signals or restrictions in the complexity of the source encoding method, the source encoding QE can usually be implemented only suboptimally, i.e. the symbol sequences

SY contained in the compressed information still contain redundant information.

As shown in Figure 2, the symbols of the symbol sequence SY, or the corresponding symbol values c,j are mapped by a binary mapping BM (allocation rule) which is frequently described as part of the source encoding QE, to a sequence BCW of binary code words bcw,j which in each case have a number of bit positions b,i. Thus, to each symbol value c,j, a different binary code word bcw,j is allocated which differ by having different binary values at one or more bit positions b,i. In this process, the index j identifies the different values of the symbols or the different code words and the indices i and, in the text which follows, k,q identify the position at which a corresponding value is located.

If these binary code words bcw,j are processed further, for example, successively as a sequence BCW of binary code words, a sequence u of source-encoded bit positions u_q is produced which can be embedded in a frame structure, each bit position u_q being permanently allocated to a particular bit position b,i of a particular code word bcw,j. Thus, a frame with 260 bit positions u_q is produced every 20 milliseconds, for example in GSM full-rate encoding.

Figure 2 shows a frame structure of a frame k produced in this manner. The source-encoded bit positions u_q have either the value "+1" or "-1" or "0". The index 1 runs from 0 to Q-1 within a frame, Q being the number of source-encoded bit positions u_q in a frame. In each frame, the bit positions can be divided, for example,

into three classes having different significance and sensitivity to co-channel interference.

The source-encoded bit sequences u are coded against co-channel interference in a channel encoder CE like a
5   convolutional encoder, in such a manner that the lowest bit-error probability occurs in the most important class. For this purpose, the 50 most significant bits (Class 1a) are first protected by 3 bits of a cyclic redundancy check (CRC). The next 132 significant bits (Class 1b) are
10   regrouped with the aforementioned 53 bits and, together, convolutionally encoded with a ½ rate together with four tail bits. The 78 less significant bits (Class 2) are transmitted uncoded.

These bit sequences that have been x channel-encoded
15   in this manner are processed further in a modulator, not shown, and are then transmitted via a transmission link CH. During the transmission, disturbances occur, for example, fading, described by a fading factor ak, and noise, described by the noise vector N0.
20   The transmission link CH is located between a transmitter and a receiver. If necessary, the receiver contains an antenna, not shown, for receiving the signals transmitted via the transmission link CH, a sampling device, a demodulator for demodulating the signals and
25   an equalizer for eliminating the inter-symbol interference. These devices are also not shown in Figure 1 for reasons of simplification. Any possible interleaving and deinterleaving are also not shown.

The equalizer outputs received values of a received
30   sequence y. Due to the interference in the transmission via the transmission link CH, the received values have

SUBSTITUTE SPECIFICATION

values which deviate from "+1" and "-1", for example "+0.2" or "-3.7".

The channel encoding is cancelled in a channel decoder CD. For this purpose, the binary values of the
5   individual received bit positions $\underline{u}_q$ and $\underline{b,i}$ are decided on the basis of the received values of the received sequence y. Apart from the channel status information CSI, the residual redundancy of the symbol sequences SY described above can be utilized in the so-called source-
10   controlled or common channel decoding CD for correcting bit errors or, respectively, improving the decoding. In principle, there are two possibilities for this:

•   In the sense of a priori information APRI, the redundant information on the frequency of the
15   symbol values c,j, and thus also the frequency of the binary values of certain bit positions b,i, and the correlation of the symbols to each other and thus also the correlation of the binary values of certain bit positions b,i to each other, is
20   utilized directly in the channel decoder CD in that, for example, this information is first determined by means of some test source signals in a test source encoder or, respectively, by means of a test source encoder, and this information is then
25   stored in a storage unit allocated to the channel decoder CD and utilized for channel decoding in that it is used, for example, for determining a threshold from which, for example, the binary value "1" is decided for a value of the received sequence
30   y.

- The redundant information on the frequency of the symbol values c,j, and thus also the frequency of the binary values of certain bit positions b,i, and the correlation of the symbols to each other and
5 thus also the correlation of the binary values of certain bit positions b,i to each other, is determined after the channel decoding CD in the sense of a posteriori information. The a posteriori information APOI can be determined directly after
10 the channel decoder CD or after or during the source decoding QD.

Such a method is described in "J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pages 2449-2457, Sept. 1995",
15 especially on pages 2451 and 2452, the decoding process of the channel decoder being controlled both by the transmitted code bits and by a priori/a posteriori information on the probable value of some significant source bits. In the case of the VA (Viterbi algorithm)
20 decoding, this method has been called Apri-VA.
For the channel decoding CD, it is also possible to use, for example, a SOVA (soft-output Viterbi algorithm). A SOVA is an algorithm which outputs not only a decision value but, furthermore, also specifies the probability
25 with which the decided value is present.
After the completed channel decoding CD, the received channel-decoded bit sequences $\underline{u}$ or, respectively, the binary code words $\underline{bcw,j}$ contained therein are mapped back in a reverse binary mapper BD
30 onto received symbols of received symbol sequences $\underline{SY}$

SUBSTITUTE SPECIFICATION

which are then processed into source signals QS in the source decoding QD and are output at the information sink S.

In the text which follows, four possible different binary mappings BM are presented:

- Natural binary code NBC
- Folded binary code FBC
- Gray binary code GBC
- Minimum distance code MBC

These four binary mappings are shown by way of example with in each case 4 bit positions in the table below:

Symbol	Code word bcw,j NBC				Code word bcw,j FBC				Code word bcw,j GBC				Code word bcw,j MDC			
c,j	$b3$	$b2$	$b1$	$b0$	$b3$	$b2$	$b1$	$b0$	$b3$	$b2$	$b1$	$b0$	$b3$	$b2$	$b1$	$b0$
c0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1
c1	0	0	0	1	0	1	1	0	0	0	0	1	0	1	1	0
c2	0	0	1	0	0	1	0	1	0	0	1	1	0	1	0	1
c3	0	0	1	1	0	1	0	0	0	0	1	0	0	0	1	1
c4	0	1	0	0	0	0	1	1	0	1	1	0	0	0	1	0
c5	0	1	0	1	0	0	1	0	0	1	1	1	0	0	1	0
c6	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1
c7	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0
c8	1	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0
c9	1	0	0	1	1	0	0	1	1	1	0	1	1	0	0	1
c10	1	0	1	0	1	0	1	0	1	1	1	1	1	0	1	0
c11	1	0	1	1	1	0	1	1	1	1	1	0	1	1	0	0
c12	1	1	0	0	1	1	0	0	1	0	1	0	1	0	1	1
c13	1	1	0	1	1	1	0	1	1	0	1	1	1	1	0	1
c14	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	0
c15	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1
#(bit change)	1	3	7	15	1	2	6	14	1	2	4	8	1	6	10	10

In known methods for source encoding, the symbols
or[, respectively,] parameters have been mapped to the
natural binary code NBC after the source encoding QE and
source quantization in an unsorted manner. In
5   consequence, the source-controlled channel decoding CD
was also only applied to such source-encoded bit
positions b,i.

If the symbols or the symbol sequences SY consisting
of symbols still contain redundant information, i.e. the
10 relative frequencies of the symbol values c,j are
distributed unevenly, or some symbols are correlated to
one another, there is automatically also redundant
information in some bit positions b,i. In elaborate
simulations with simulation methods developed especially
15 for this purpose it was found that, due to the uneven
distribution of the symbol values c,j due to the
deliberate use of certain binary mappings BM, the
residual redundancy contained in the symbol sequences SY
can be utilized particularly well for improving the error
20 correction in the channel decoding CD.

The present invention makes particularly good use
of the residual redundancy existing in the symbol
sequence SY for decoding the binary values of the bit
positions or, respectively, of bit positions b,i, because
25 instead of employing some randomly selected mapping BM
for the binary mapping, the symbols or parameters are
first sorted in accordance with their probability and the
natural binary code is allocated to the symbol structure
thus produced.

30 Thus, the natural binary code (NBC) is allocated to
the symbols sorted in accordance with their probability
of occurrence in such a manner that a code word which has
the first binary value at all bit positions, or a code
word which has the second binary value at all bit
35 positions, is allocated to the symbol occurring most

frequently, and a code word which exhibits the second binary value at all bit positions or a code word which exhibits the first binary value at all bit positions is allocated to the symbol occurring most rarely.

5   This leads to an efficient mapping of the symbol redundancy to the individual bit position redundancy; as a result, more redundant information about the binary values of the individual bit positions b,i can be utilized for error correction. In addition, more

10   redundant information can be used for decoding the most significant bit than for decoding the second most significant bit. The decoding results can be particularly improved by a method according to the invention especially for mapping digital data or vector-quantized

15   parameters to code words - as is shown by simulation results.

     In the source-controlled channel decoding CD, the residual redundancy (uneven distribution) existing in the source-encoded symbol sequences SY can then be utilized

20   more easily and more efficiently since the redundancy existing at the symbol level is thus converted into a redundancy (uneven distribution) existing at the bit level which can be used directly by the source-controlled channel decoder (e.g. Apri-VA). Using this method, an

25   improved quality can be achieved in the transmission of the source signals QS (sound, voice, etc.). The additional computational effort for such sorting before binary mapping BM is low and usually can be neglected.

     Such binary mapping BM can be implicitly integrated

30   in the source encoder and decoder. For codecs which are already standardized such as the GSM full-rate/enhanced full-rate voice codec, however, it means a modification both in the receiver and in the transmitter. However, this modification is possible without any great hardware

35   alteration. In the GSM system, it is only necessary, in

terms of infrastructure, to add the binary mapping and inverse mapping in the TRAU (transcoder and rate adapter unit), the BTS (base transceiver station), BSC (base station controller) etc. remain unchanged.

5   Figure 3 shows the frequency distribution of the symbol values c,j and the allocated binary code words bcw,j. It can be seen here that in the case of the NBC at the first bit position $b1$, the probability for the binary value "0" is very much greater than that for the

10   binary value "1", especially under the condition that symbol $c1$ or $c2$ has been sent. This information can be utilized in the sense of a posteriori or a priori information in the source-controlled channel decoding in order to decide the binary value of the bit position $b1$

15   or, respectively, to determine the threshold used for this, and thus to make the decision more reliable.

       Thus, the decoding can be improved further if information on the symbol value c,j probably transmitted is also used.

20   If the symbols have not been sorted before the binary mapping, the a posteriori or a priori information (that is to say the probability for a binary value "0") used in the source-controlled channel decoding would generally be less and the decoding of the bit positions

25   could not be carried out so reliably.

       In a variant of the embodiment of the invention, all or some of the bit positions of code words are interchanged after sorting and mapping symbols onto code words.

30   In an embodiment of the invention, the information consisting of symbol sequences SY is mapped to binary code words bcw,j having in each case a plurality of bit positions b,i in such a manner that even the correlation between the binary values of the corresponding bit

35   positions b,i,k (or uq,k at frame level) and $b,i,k+1$ (or

SUBSTITUTE SPECIFICATION

uq,k+1 at frame level) of successive frames k, k+1 is large. In this arrangement, in particular, a correlation of the source bits is taken into consideration. The basic concept of this method consists in that corresponding
5   symbols do not change very often between two successive frames and there is thus a redundancy in the transmission. This correlation between successive frames can be utilized especially well at the receiver end, using an APRI SOVA (a priori soft-output Viterbi
10   algorithm) decoder if a binary mapping BM is selected in such a manner that the correlation between the binary values of the corresponding bit positions of the successive frames is large.

In elaborate simulations, the use of the GBC as
15   binary mapping has thus been found to be particularly advantageous, especially if the symbols have a Gaussian or an anti-Gaussian distribution which is often the case.

In source-controlled channel decoding CD, the inter-frame correlation, that is to say the statistical
20   dependence between temporally and/or spatially adjacent signal samples can also be utilized. To estimate the a priori/a posteriori information, for example, the empirical "HUK algorithm", which is described in "J. Hagenauer, "Source-controlled channel decoding", IEEE
25   Trans. Commun., Vol. 43, pages 2449-2457, Sept. 1995", or a method based on Kalman filters can also be used for source-controlled channel decoding.

In a further variant of the embodiment, the information consisting of symbol sequences SY is mapped
30   to binary code words bcw,j having in each case a plurality of bit positions b,i in such a manner that, in the case of a wrongly detected binary value, the error in the detected symbol or, respectively, the output source signal QS is small. By means of a suitable binary
35   mapping BM, the source signals will thus respond less

sensitively to co-channel interference. In elaborate simulations, the use of the FBC as binary mapping has thus been found to be particularly advantageous, especially if the symbols have a Gaussian or an anti-Gaussian distribution which is often the case.

5

Variants of the embodiment are also possible in which the binary mapping BM is selected in such a manner that a number of aspects of the variants described above are combined in the sense of a compromise.

10

To carry out the method explained above, a program-controlled signal processor integrated, for example, in radio equipment, such as a mobile station or base station of a mobile radio system, is provided which uses one of the methods described above for coding and/or decoding information to be transmitted.

15

Although modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of the inventor's contribution to the art.

20

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Case Number: P01,0052

**International Application No.**   PCT/DE99/01993

International Filing Date: 01 July 1999

Title: METHOD FOR CODING, DECODING AND TRANSMITTING INFORMATION, SIGNAL PROCESSOR AND RADIO EQUIPMENT

Applicant: WEN XU

Enclosed are the following documents:

     International Application as filed, drawings, attached; translation thereof
     Submission of Substitute Specification including Red-lined version
     Information Disclosure Statement
     Submission of Ready to Publish Drawings
     Request for Approval of Drawing Changes
     PTO 1390 in duplicate;
     Declaration
     Assignment (separate envelope)
     Government Filing Fee
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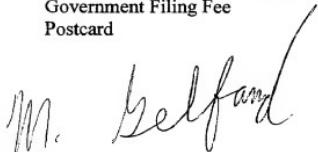
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S P E C I F I C A T I O N

TITLE

"METHOD FOR CODING, DECODING AND TRANSMITTING

INFORMATION, SIGNAL PROCESSOR AND RADIO EQUIPMENT"

5   BACKGROUND OF THE INVENTION

Field of the Invention

[Description

Method for coding, decoding and transmitting information,

signal processor and radio equipment]

10   The present invention relates to a method for coding

and   decoding   information,   especially   for   digital

transmission or storage.

Description of the Prior Art

      Source signals or source information such as voice,

15   sound, image and video signals almost always contain

statistical   redundancy,   that   is   to   say   redundant

information. This redundancy can be greatly reduced by

source encoding, making it possible to transmit and/or

store the source signal efficiently. This redundancy

20   reduction eliminates redundant signal contents which are

based on the prior knowledge of, for example, statistical

parameters   of   the   signal   variation,   before   the

transmission. After the transmission, these components

are added to the signal again in the source decoding, so

25   that no loss of quality can be detected objectively.

      Due to the incomplete knowledge of the source

signals or restrictions in the complexity of the source

encoding method, the source encoding [can] usually only

can be implemented in a suboptimum way, that is to say

30   the compressed data still contain a certain redundancy

even after the source encoding. In previous methods for

source   encoding,   the   source   signals   are   frequently

compressed to form symbols or quantized parameters which
are then mapped to binary code words in accordance with
an allocation rule, the allocation rule having been
selected more or less randomly until now.

5   On the other hand, it is usual to deliberately add
redundancy again by channel encoding during the signal
transmission in order to largely eliminate the effect of
co-channel interference on the transmission. Additional
redundant bits thus enable the receiver or, respectively,

10   decoder to detect and possibly also to correct errors.

It has long been one of the basic [premisses]
premises of information theory that source encoding and
channel encoding can be carried out independently of one
another in order to achieve an optimum result. According

15   to this principle, the design of the source decoder
[only] depends only on the source characteristics whereas
the channel encoding arrangement should [only] depend
only on the channel characteristics. This principle can
be correct if the source encoder delivers statistically

20   independent and thus uncorrelated symbols of equal
probability and the decoding delay can be of any
magnitude. In practical applications, however, these
prerequisites are not met, as a rule. The output signal
of the source encoder or, respectively, the symbol

25   sequences output by it frequently exhibit a residual
redundancy and, at the same time, the permissible delay
is restricted, especially in voice transmission.

It is known to utilize this residual redundancy of
the source-encoded symbol sequences in the so-called

30   source-controlled channel decoding. In this process, the
decoding process of the channel decoder is controlled,
on the one hand, by the transmitted bits and, on the
other hand, by a priori/a posteriori information on the

most probable value of some important source bits. The
source information thus has an influence on the result
of the channel decoding. In the case of the Viterbi
algorithm decoding, this method is called an a priori

5   Viterbi algorithm. When such a method is used, only the
receiver needs to be modified. Thus, the printed document
J. Hagenauer, "Source-controlled channel decoding", IEEE
Trans. Commun., Vol. 43, pages 2449-2457, September 1995,
teaches to use the inter-frame correlation, that is to

10   say the statistical dependence between temporally and/or
spatially adjacent signal samples in the source-
controlled channel decoding.

Investigations have also shown that there is residual redundancy not only between bits of successive frames but also between the bits of a parameter within a frame due to the uneven distribution of the parameter

5   values which, in turn, is attributable to the non-stationary condition of the source signals.

SUMMARY OF THE INVENTION

The present invention has the object of achieving information transmission or information storage with the

10   fewest possible errors and the least possible expenditure.

According to the invention, the abovementioned object is achieved [by the features of the independent claims].

15   [Accordingly, the invention is based on the concept of first] First sorting the symbols in accordance with their relative frequency and [to allocate] allocating the natural binary code to the sorting result.

The invention has the result that the error rate of

20   the decoded bits can be reduced without additional expenditure, and thus information can be transmitted with fewer disturbances.

In the text which follows, the invention will be described in greater detail with reference to preferred

25   illustrative embodiments. In this connection, it is especially the digital transmission of the information which is described. Nevertheless, the information can also be applied to the storage of information since the writing of information to a storage medium and the

30   reading of information from a storage medium correspond to the sending of information and the receiving of information with regard to the present invention.

The term "decoding" is frequently used for describing the decoding of channel-encoded bit positions whilst the term "detection" is used if generally the binary values of a bit position are decided. Since the present invention is advantageously applicable to both cases, the term "decoding" also contains the process of detection within the context of the present patent application.

[The figures listed below are used for explaining the embodiments of the invention. In the figures:

Figure 1   shows a diagrammatic representation of a communication chain,

Figure 2   shows a diagrammatic representation of the connection between symbols and the source-encoded bit sequences in a frame structure,

Figure 3   shows a frequency distribution of the symbols and of the binary values depending on binary mapping.]

Description of the Drawings

Figure 1 is a schematic representation of a communication chain constructed and operated in accordance with the invention.

Figure 2 is a diagram showing the relationship between symbols and the source-encoded bit sequences in a frame structure, in accordance with the invention.

Figure 3 illustrates the frequency distribution of the symbols and the binary values dependent on binary mapping, in accordance with the invention.

Description of the Preferred Embodiments

   Figure 1 shows a source Q which generates source
signals QS which are compressed into symbol sequences SY
consisting of symbols by a source encoder QE like the GSM
5   full-rate voice encoder. Here, the symbols have one of
the values c,j (symbol value). In parametric source
encoding methods, the source signals QS (e.g. voice)
generated by the source Q are subdivided into blocks
(e.g. time frames) and these are processed separately.
10   The source encoder QE generates quantized parameters
(e.g. voice coefficients) which are also called symbols
of a symbol sequence SY in the text which follows and
which reflect the characteristics of the source in the
current block in a certain manner (e.g. spectrum of the
15   voice, filter parameter). These symbols have a certain
symbol value c,j after the quantization.

   Thus, for example, the GSM full-rate encoder
generates 76 parameters, of which parameters 0 to 7 are
the so-called LAR (logarithmic area ratio) coefficients
20   which are generated during the LPC (linear prediction
coding) analysis. Parameters 9, 26, 43 and 60 are
similarity [figures] values for the so-called LTP (long-
term prediction). Each frame also contains four XMAX
coefficients (or parameters) from the so-called RPE
25   (residual pulse excitation) analysis which change only
little from frame to frame.

   Due to the incomplete knowledge of the source
signals or restrictions in the complexity of the source
encoding method, the source encoding QE can usually be
30   implemented only suboptimally, i.e. the symbol sequences
SY contained in the compressed information still contain
redundant information.

As shown in Figure 2, the symbols of the symbol sequence SY$_L$ or [, respectively,] the corresponding symbol values c,j are mapped by a binary mapping BM (allocation rule) which is frequently described as part of the source encoding QE, to a sequence BCW of binary code words bcw,j which in each case have a number of bit positions b,i. Thus, to each symbol value c,j, a different binary code word bcw,j is allocated which differ by having different binary values at one or more bit positions b,i. In this process, the index j identifies the different values of the symbols or the different code words and the indices i and, in the text which follows, k,q identify the position at which a corresponding value is located.

If these binary code words bcw,j are processed further, for example, successively as a sequence BCW of binary code words, a sequence u of source-encoded bit positions u_q is produced which can be embedded in a frame structure, each bit position u_q being permanently allocated to a particular bit position b,i of a particular code word bcw,j. Thus, a frame with 260 bit positions u_q is produced every 20 milliseconds, for example in GSM full-rate encoding.

Figure 2 shows a frame structure of a frame k produced in this manner. The source-encoded bit positions u_q have either the value "+1" or "-1" or [, respectively,] "0". The index 1 runs from 0 to Q-1 within a frame, Q being the number of source-encoded bit positions u_q in a frame. In each frame, the bit positions can be divided, for example, into three classes having different significance and sensitivity to co-channel interference.

The source-encoded bit sequences u are coded against co-channel interference in a channel encoder CE like a convolutional encoder, in such a manner that the lowest

bit-error probability occurs in the most important class. For this purpose, the 50 most significant bits (Class 1a) are first protected by 3 bits of a cyclic redundancy check (CRC). The next 132 significant bits (Class 1b) are

5   regrouped with the aforementioned 53 bits and, together, convolutionally encoded with a 1/2 rate together with four tail bits. The 78 less significant bits (Class 2) are transmitted uncoded.

These bit sequences <u>that have been</u> x channel-encoded

10   in this manner are processed further in a modulator, not shown, and are then transmitted via a transmission link CH. During the transmission, disturbances occur, for example, fading, described by a fading factor ak, and noise, described by the noise vector N0.

15   The transmission link CH is located between a transmitter and a receiver. If necessary, the receiver contains an antenna, not shown, for receiving the signals transmitted via the transmission link CH, a sampling device, a demodulator for demodulating the signals and

20   an equalizer for eliminating the inter-symbol interference. These devices are also not shown in Figure 1 for reasons of simplification. Any possible interleaving and deinterleaving are also not shown.

The equalizer outputs received values of a received

25   sequence y. Due to the interference in the transmission via the transmission link CH, the received values have values which deviate from "+1" and "-1", for example "+0.2" or "-3.7".

The channel encoding is cancelled in a channel

30   decoder CD. For this purpose, the binary values of the individual received bit positions $\underline{u}_q$ and[, respectively,] <u>b,i</u> are decided on the basis of the received values of the received sequence y. Apart from the channel status

information CSI, the residual redundancy of the symbol sequences SY described above can be utilized in the so-called source-controlled or common channel decoding CD for correcting bit errors or, respectively, improving the
5   decoding. In principle, there are two possibilities for this:

•   In the sense of a priori information APRI, the redundant information on the frequency of the symbol values c,j, and thus also the frequency of the binary
10   values of certain bit positions b,i, and the correlation of the symbols to each other and thus also the correlation of the binary values of certain bit positions b,i to each other, is utilized directly in the channel decoder CD in that, for example, this information is
15   first determined by means of some test source signals in a test source encoder or, respectively, by means of a test source encoder, and this information is then stored in a storage unit allocated to the channel decoder CD and utilized for channel decoding in that it is used, for
20   example, for determining a threshold from which, for example, the binary value "1" is decided for a value of the received sequence y.

•   The redundant information on the frequency of the symbol values c,j, and thus also the frequency of
25   the binary values of certain bit positions b,i, and the correlation of the symbols to each other and thus also the correlation of the binary values of certain bit positions b,i to each other, is determined after the channel decoding CD in the
30   sense of a posteriori information. The a posteriori information APOI can be determined directly after

the channel decoder CD or after or during the source decoding QD.

Such a method is described in "J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pages 2449-2457, Sept. 1995", especially on pages 2451 and 2452, the decoding process of the channel decoder being controlled both by the transmitted code bits and by a priori/a posteriori information on the probable value of some significant source bits. In the case of the VA (Viterbi algorithm) decoding, this method has been called Apri-VA.

For the channel decoding CD, it is also possible to use, for example, a SOVA (soft-output Viterbi algorithm). A SOVA is an algorithm which outputs not only a decision value but, furthermore, also specifies the probability with which the decided value is present.

After the completed channel decoding CD, the received channel-decoded bit sequences $\underline{u}$ or, respectively, the binary code words $\underline{bcw,i}$ contained therein are mapped back [DB] <u>in a reverse binary mapper BD</u> onto received symbols of received symbol sequences $\underline{SY}$ which are then processed into source signals $\underline{QS}$ in the source decoding QD and are output at the information sink S.

In the text which follows, four possible different binary mappings BM are presented:

- Natural binary code NBC
- Folded binary code FBC
- Gray binary code GBC
- Minimum distance code MBC

These four binary mappings are shown by way of example with in each case 4 bit positions in the table below:

Symbol	Code word bcw,j				Code word bcw,j				Code word bcw,j				Code word bcw,j			
	NBC				FBC				GBC				MDC			
c,j	b3	b2	b1	b0	b3	b2	b1	b0	b3	b2	b1	b0	b3	b2	b1	b0
c0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1
c1	0	0	0	1	0	1	1	0	0	0	0	1	0	1	1	0
c2	0	0	1	0	0	1	0	1	0	0	1	1	0	1	0	1
c3	0	0	1	1	0	1	0	0	0	0	1	0	0	0	1	1
c4	0	1	0	0	0	0	1	1	0	1	1	0	0	1	0	0
c5	0	1	0	1	0	0	1	0	0	1	1	1	0	0	1	0
c6	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1
c7	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0
c8	1	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0
c9	1	0	0	1	1	0	0	1	1	1	0	1	1	0	0	1
c10	1	0	1	0	1	0	1	0	1	1	1	1	1	0	1	0
c11	1	0	1	1	1	0	1	1	1	1	1	0	1	1	0	0
c12	1	1	0	0	1	1	0	0	1	0	1	0	1	0	1	1
c13	1	1	0	1	1	1	0	1	1	0	1	1	1	1	0	1
c14	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	0
c15	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1
#(bit change)	1	3	7	15	1	2	6	14	1	2	4	8	1	6	10	10

In [previously] known methods for source encoding, the symbols or[, respectively,] parameters have been mapped to the natural binary code NBC after the source encoding QE and source quantization in an unsorted manner. In consequence, the source-controlled channel decoding CD was also only applied to such source-encoded bit positions b,i.

If the symbols or[, respectively,] the symbol sequences SY consisting of symbols still contain redundant information, i.e. the relative frequencies of the symbol values c,j are distributed unevenly, or some symbols are correlated to one another, there is automatically also redundant information in some bit positions b,i. In elaborate simulations with simulation methods developed especially for this purpose it was found that, due to the uneven distribution of the symbol values c,j due to the deliberate use of certain binary mappings BM, the residual redundancy contained in the symbol sequences SY can be utilized particularly well for

improving the error correction in the channel decoding CD.

   The present invention makes particularly good use of the residual redundancy existing in the symbol sequence SY for decoding the binary values of the bit positions or, respectively, of bit positions b,i$_L$ [in that it is not] <u>because instead of employing</u> some randomly selected mapping BM [which is selected but, instead,] for the binary mapping, the symbols or parameters[, respectively,] are first sorted in accordance with their probability and the natural binary code is allocated to the symbol structure thus produced.

   Thus, the natural binary code (NBC) is allocated to the symbols sorted in accordance with their probability of occurrence in such a manner that a code word which has the first binary value at all bit positions, or a code word which has the second binary value at all bit positions, is allocated to the symbol occurring most frequently, and a code word which exhibits the second binary value at all bit positions or a code word which exhibits the first binary value at all bit positions is allocated to the symbol occurring most rarely.

   This leads to an efficient mapping of the symbol redundancy to the individual bit position redundancy; as a result, more redundant information about the binary values of the individual bit positions b,i can be utilized for error correction. In addition, more redundant information can be used for decoding the most significant bit than for decoding the second most significant bit. The decoding results can be particularly improved by a method according to the invention especially for mapping digital data or vector-quantized parameters to code words - as is shown by simulation results.

   In the source-controlled channel decoding CD, the residual redundancy (uneven distribution) existing in the source-encoded symbol sequences SY can then be utilized more easily and more efficiently since the redundancy existing at the symbol level is thus converted into a redundancy (uneven distribution) existing at the bit level which can be used directly by the source-controlled

channel decoder (e.g. Apri-VA). Using this method, an improved quality can be achieved in the transmission of the source signals QS (sound, voice, etc.). The additional computational effort for such sorting before
5   binary mapping BM is low and <u>usually</u> can be [usually] neglected.

Such binary mapping BM can be implicitly integrated in the source encoder and decoder. For codecs which are already standardized such as the GSM full-rate/enhanced
10   full-rate voice codec, however, it means a modification both in the receiver and in the transmitter. However, this modification is possible without any great hardware alteration. In the GSM system, it is only necessary, in terms of infrastructure, to add the binary mapping and
15   inverse mapping in the TRAU (transcoder and rate adapter unit), the BTS (base transceiver station), BSC (base station controller) etc. remain unchanged.

Figure 3 shows the frequency distribution of the symbol values c_j and the allocated binary code words
20   bcw_j. It can be seen here that in the case of the NBC at the first bit position b_1, the probability for the binary value "0" is very much greater than that for the binary value "1", especially under the condition that symbol c_1 or c_2 has been sent. This information can be
25   utilized in the sense of a posteriori or a priori information in the source-controlled channel decoding in order to decide the binary value of the bit position b_1 or, respectively, to determine the threshold used for this, and thus to make the decision more reliable.

30   Thus, the decoding can be improved further if information on the symbol value c_j probably transmitted is also used.

If the symbols have not been sorted before the binary mapping, the a posteriori or a priori information
35   (that is to say the probability for a binary value "0") used in the source-controlled channel decoding would generally be less and the decoding of the bit positions could not be carried out so reliably.

In a variant of the embodiment of the invention, all
40   or some of the bit positions of code words are

interchanged after sorting and mapping symbols onto code words.

In an embodiment of the invention, the information consisting of symbol sequences SY is mapped to binary code words bcw,j having in each case a plurality of bit positions b,i in such a manner that even the correlation between the binary values of the corresponding bit positions b,i,k (or uq,k at frame level) and b,i,k+1 (or uq,k+1 at frame level) of successive frames k, k+1 is large. In this arrangement, in particular, a correlation of the source bits is taken into consideration. The basic concept of this method consists in that corresponding symbols do not change very often between two successive frames and there is thus a redundancy in the transmission. This correlation between successive frames can be utilized especially well at the receiver end, using an APRI SOVA (a priori soft-output Viterbi algorithm) decoder if a binary mapping BM is selected in such a manner that the correlation between the binary values of the corresponding bit positions of the successive frames is large.

In elaborate simulations, the use of the GBC as binary mapping has thus been found to be particularly advantageous, especially if the symbols have a Gaussian or an anti-Gaussian distribution which is often the case.

In source-controlled channel decoding CD, the inter-frame correlation, that is to say the statistical dependence between temporally and/or spatially adjacent signal samples can also be utilized. To estimate the a priori/a posteriori information, for example, the empirical "HUK algorithm", which is described in "J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pages 2449-2457, Sept. 1995", or a method based on Kalman filters can also be used for source-controlled channel decoding.

In a further variant of the embodiment, the information consisting of symbol sequences SY is mapped to binary code words bcw,j having in each case a plurality of bit positions b,i in such a manner that, in the case of a wrongly detected binary value, the error in the detected symbol or, respectively, the output

source signal QS is small. By means of a suitable binary mapping BM, the source signals will thus respond less sensitively to co-channel interference. In elaborate simulations, the use of the FBC as binary mapping has

5   thus been found to be particularly advantageous, especially if the symbols have a Gaussian or an anti-Gaussian distribution which is often the case.

Variants of the embodiment are also possible in which the binary mapping BM is selected in such a manner

10   that a number of aspects of the variants described above are combined in the sense of a compromise.

To carry out the method explained above, a program-controlled signal processor integrated, for example, in radio equipment, such as a mobile station or base station

15   of a mobile radio system, is provided which uses one of the methods described above for coding and/or decoding information to be transmitted.

Although modifications and changes may be suggested by those skilled in the art, it is the intention of the

20   inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of the inventor's contribution to the art.

Description

Method   for   coding,   decoding   and   transmitting
5   information, signal processor and radio equipment

        The present invention relates to a method for
   coding and decoding information, especially for digital
   transmission or storage.
10   Source signals or source information such as
   voice, sound, image and video signals almost always
   contain   statistical   redundancy,   that   is   to   say
   redundant information. This redundancy can be greatly
   reduced by source encoding, making it possible to
15 transmit and/or store the source signal efficiently.
   This redundancy reduction eliminates redundant signal
   contents which are based on the prior knowledge of, for
   example,   statistical   parameters   of   the   signal
   variation,   before   the   transmission.   After   the
20 transmission, these components are added to the signal
   again in the source decoding, so that no loss of
   quality can be detected objectively.
        Due to the incomplete knowledge of the source
   signals or restrictions in the complexity of the source
25 encoding method, the source encoding can usually only
   be implemented in a suboptimum way, that is to say the
   compressed data still contain a certain redundancy even
   after the source encoding. In previous methods for
   source encoding, the source signals are frequently
30 compressed to form symbols or quantized parameters
   which are then mapped to binary code words in
   accordance with an allocation rule, the allocation rule
   having been selected more or less randomly until now.
        On the other hand, it is usual to deliberately
35 add redundancy again by channel encoding during the
   signal transmission in order to largely eliminate the
   effect of co-channel interference on the transmission.
   Additional

redundant   bits   thus   enable   the   receiver   or,
respectively, decoder to detect and possibly also to
correct errors.

5   It has long been one of the basic premisses of
information theory that source encoding and channel
encoding can be carried out independently of one
another in order to achieve an optimum result.
According to this principle, the design of the source
decoder only depends on the source characteristics
10   whereas the channel encoding arrangement should only
depend on the channel characteristics. This principle
can be correct if the source encoder delivers
statistically independent and thus uncorrelated symbols
of equal probability and the decoding delay can be of
15   any magnitude. In practical applications, however,
these prerequisites are not met, as a rule. The output
signal of the source encoder or, respectively, the
symbol sequences output by it frequently exhibit a
residual redundancy and, at the same time, the
20   permissible delay is restricted, especially in voice
transmission.

It is known to utilize this residual redundancy
of the source-encoded symbol sequences in the so-called
source-controlled channel decoding. In this process,
25   the decoding process of the channel decoder is
controlled, on the one hand, by the transmitted bits
and, on the other hand, by a priori/a posteriori
information on the most probable value of some
important source bits. The source information thus has
30   an influence on the result of the channel decoding. In
the case of the Viterbi algorithm decoding, this method
is called an a priori Viterbi algorithm. When such a
method is used, only the receiver needs to be modified.
Thus, the printed document J. Hagenauer, "Source-
35   controlled channel decoding", IEEE Trans. Commun.,
Vol. 43, pages 2449-2457, September 1995, teaches to
use the inter-frame correlation, that is to say the

statistical dependence between temporally and/or spatially adjacent signal samples in the source-controlled channel decoding.

Investigations have also shown that there is residual redundancy not only between bits of successive frames but also between the bits of a parameter within a frame due to the uneven distribution of the parameter values which, in turn, is attributable to the non-stationary condition of the source signals.

The present invention has the object of achieving information transmission or information storage with the fewest possible errors and the least possible expenditure.

According to the invention, the abovementioned object is achieved by the features of the independent claims.

Accordingly, the invention is based on the concept of first sorting the symbols in accordance with their relative frequency and to allocate the natural binary code to the sorting result.

The invention has the result that the error rate of the decoded bits can be reduced without additional expenditure, and thus information can be transmitted with fewer disturbances.

In the text which follows, the invention will be described in greater detail with reference to preferred illustrative embodiments. In this connection, it is especially the digital transmission of the information which is described. Nevertheless, the information can also be applied to the storage of information since the writing of information to a storage medium and the reading of information from a storage medium correspond to the sending of information and the receiving of information with regard to the present invention.

The term "decoding" is frequently used for describing the decoding of channel-encoded bit positions whilst the term "detection" is used if generally the binary values of a bit position are decided. Since the present invention is advantageously applicable to both cases,

the term "decoding" also contains the process of detection within the context of the present patent application.

5 The figures listed below are used for explaining the embodiments of the invention. In the figures:

Figure 1   shows a diagrammatic representation of a communication chain,

10

Figure 2   shows a diagrammatic representation of the connection between symbols and the source-encoded bit sequences in a frame structure,

15 Figure 3   shows a frequency distribution of the symbols and of the binary values depending on binary mapping.

20 Figure 1 shows a source Q which generates source signals QS which are compressed into symbol sequences SY consisting of symbols by a source encoder QE like the GSM full-rate voice encoder. Here, the symbols have one of the values c,j (symbol value). In parametric source encoding methods, the source signals

25 QS (e.g. voice) generated by the source Q are subdivided into blocks (e.g. time frames) and these are processed separately. The source encoder QE generates quantized parameters (e.g. voice coefficients) which are also called symbols of a symbol sequence SY in the

30 text which follows and which reflect the characteristics of the source in the current block in a certain manner (e.g. spectrum of the voice, filter parameter). These symbols have a certain symbol value c,j after the quantization.

35 Thus, for example, the GSM full-rate encoder generates 76 parameters, of which parameters 0 to 7 are

the so-called LAR (logarithmic area ratio) coefficients
which are generated during the LPC (linear prediction
coding) analysis. Parameters

9, 26, 43 and 60 are similarity figures for the so-called LTP (long-term prediction). Each frame also contains four XMAX coefficients (or parameters) from the so-called RPE (residual pulse excitation) analysis
5   which change only little from frame to frame.

Due to the incomplete knowledge of the source signals or restrictions in the complexity of the source encoding method, the source encoding QE can usually be implemented only suboptimally, i.e. the symbol
10   sequences SY contained in the compressed information still contain redundant information.

As shown in Figure 2, the symbols of the symbol sequence SY or, respectively, the corresponding symbol values c,j are mapped by a binary mapping BM
15   (allocation rule) which is frequently described as part of the source encoding QE, to a sequence BCW of binary code words bcw,j which in each case have a number of bit positions b,i. Thus, to each symbol value c,j, a different binary code word bcw,j is allocated which
20   differ by having different binary values at one or more bit positions b,i. In this process, the index j identifies the different values of the symbols or the different code words and the indices i and, in the text which follows, k,q identify the position at which a
25   corresponding value is located.

If these binary code words bcw,j are processed further, for example, successively as a sequence BCW of binary code words, a sequence u of source-encoded bit positions u_q is produced which can be embedded in a
30   frame structure, each bit position u_q being permanently allocated to a particular bit position b,i of a particular code word bcw,j. Thus, a frame with 260 bit positions u_q is produced every 20 milliseconds, for example in GSM full-rate encoding.
35   Figure 2 shows a frame structure of a frame k produced in this manner. The source-encoded bit positions u_q have either the

value "+1" or "-1" or, respectively, "0". The index 1
runs from 0 to Q-1 within a frame, Q being the number
of source-encoded bit positions u_q in a frame. In each
frame, the bit positions can be divided, for example,
5   into three classes having different significance and
sensitivity to co-channel interference.

The source-encoded bit sequences u are coded
against co-channel interference in a channel encoder CE
like a convolutional encoder, in such a manner that the
10   lowest bit-error probability occurs in the most
important class. For this purpose, the 50 most
significant bits (Class 1a) are first protected by 3
bits of a cyclic redundancy check (CRC). The next 132
significant bits (Class 1b) are regrouped with the
15   aforementioned 53 bits and, together, convolutionally
encoded with a 1/2 rate together with four tail bits.
The 78 less significant bits (Class 2) are transmitted
uncoded.

These bit sequences x channel-encoded in this
20   manner are processed further in a modulator, not shown,
and are then transmitted via a transmission link CH.
During the transmission, disturbances occur, for
example, fading, described by a fading factor ak, and
noise, described by the noise vector N0.

25   The transmission link CH is located between a
transmitter and a receiver. If necessary, the receiver
contains an antenna, not shown, for receiving the
signals transmitted via the transmission link CH, a
sampling device, a demodulator for demodulating the
30   signals and an equalizer for eliminating the inter-
symbol interference. These devices are also not shown
in Figure 1 for reasons of simplification. Any possible
interleaving and deinterleaving are also not shown.

The equalizer outputs received values of a
35   received sequence y. Due to the interference in the
transmission

via the transmission link CH, the received values have
values which deviate from "+1" and "-1", for example
"+0.2" or "-3.7".

The channel encoding is cancelled in a channel
5   decoder CD. For this purpose, the binary values of the
individual received bit positions u_q and, respectively,
b,i are decided on the basis of the received values of
the received sequence y. Apart from the channel status
information CSI, the residual redundancy of the symbol
10   sequences SY described above can be utilized in the so-
called source-controlled or common channel decoding CD
for correcting bit errors or, respectively, improving
the decoding. In principle, there are two possibilities
for this:

15   • In the sense of a priori information APRI, the
     redundant information on the frequency of the symbol
     values c,j, and thus also the frequency of the binary
     values of certain bit positions b,i, and the
     correlation of the symbols to each other and thus
20   also the correlation of the binary values of certain
     bit positions b,i to each other, is utilized directly
     in the channel decoder CD in that, for example, this
     information is first determined by means of some test
     source signals in a test source encoder or,
25   respectively, by means of a test source encoder, and
     this information is then stored in a storage unit
     allocated to the channel decoder CD and utilized for
     channel decoding in that it is used, for example, for
     determining a threshold from which, for example, the
30   binary value "1" is decided for a value of the
     received sequence y.
   • The redundant information on the frequency of the
     symbol values c,j, and thus also the frequency of the
     binary values of certain bit positions b,i, and the
35   correlation of the symbols to each other and thus
     also the correlation of the binary values of certain
     bit positions b,i to each other, is determined after

the channel decoding CD in the sense of a posteriori
information. The a posteriori information APOI can be
determined directly

after the channel decoder CD or after or during the
source decoding QD.

Such a method is described in "J. Hagenauer,
5 "Source-controlled channel decoding", IEEE Trans.
Commun., Vol. 43, pages 2449-2457, Sept. 1995",
especially on pages 2451 and 2452, the decoding process
of the channel decoder being controlled both by the
transmitted code bits and by a priori/a posteriori
10 information on the probable value of some significant
source bits. In the case of the VA (Viterbi algorithm)
decoding, this method has been called Apri-VA.

For the channel decoding CD, it is also
possible to use, for example, a SOVA (soft-output
15 Viterbi algorithm). A SOVA is an algorithm which
outputs not only a decision value but, furthermore,
also specifies the probability with which the decided
value is present.

After the completed channel decoding CD, the
20 received channel-decoded bit sequences $\underline{u}$ or,
respectively, the binary code words $\underline{bcw,j}$ contained
therein are mapped back DB onto received symbols of
received symbol sequences $\underline{SY}$ which are then processed
into source signals $\underline{QS}$ in the source decoding QD and
25 are output at the information sink S.

In the text which follows, four possible
different binary mappings BM are presented:

• Natural binary code NBC
30 • Folded binary code FBC
• Gray binary code GBC
• Minimum distance code MBC

These four binary mappings are shown by way of example with in each case 4 bit positions in the table below:

Symbol	Code word bcw,j NBC				Code word bcw,j FBC				Code word bcw,j GBC				Code word bcw,j MDC			
c,j	$b3$	$b2$	$b1$	$b0$	$b3$	$b2$	$b1$	$b0$	$b3$	$b2$	$b1$	$b0$	$b3$	$b2$	$b1$	$b0$
c0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1
c1	0	0	0	1	0	1	1	0	0	0	0	1	0	1	1	0
c2	0	0	1	0	0	1	0	1	0	0	1	1	0	1	0	1
c3	0	0	1	1	0	1	0	0	0	0	1	0	0	0	1	1
c4	0	1	0	0	0	0	1	1	0	1	1	0	0	1	0	0
c5	0	1	0	1	0	0	1	0	0	1	1	1	0	0	1	0
c6	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1
c7	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0
c8	1	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0
c9	1	0	0	1	1	0	0	1	1	1	0	1	1	0	0	1
c10	1	0	1	0	1	0	1	0	1	1	1	1	1	0	1	0
c11	1	0	1	1	1	0	1	1	1	1	1	0	1	1	0	0
c12	1	1	0	0	1	1	0	0	1	0	1	0	1	0	1	1
c13	1	1	0	1	1	1	0	1	1	0	1	1	1	1	0	1
c14	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	0
c15	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1
#(bit change)	1	3	7	15	1	2	6	14	1	2	4	8	1	6	10	10

In previously known methods for source encoding, the symbols or, respectively, parameters have been mapped to the natural binary code NBC after the source encoding QE and source quantization in an unsorted manner. In consequence, the source-controlled channel decoding CD was also only applied to such source-encoded bit positions b,i.

If the symbols or, respectively, the symbol sequences SY consisting of symbols still contain redundant information, i.e. the relative frequencies of the symbol values c,j are distributed unevenly, or some symbols are correlated to one another,

there is automatically also redundant information in
some bit positions b,i. In elaborate simulations with
simulation methods developed especially for this
purpose it was found that, due to the uneven
5   distribution of the symbol values c,j due to the
deliberate use of certain binary mappings BM, the
residual redundancy contained in the symbol sequences
SY can be utilized particularly well for improving the
error correction in the channel decoding CD.

10   The present invention makes particularly good
use of the residual redundancy existing in the symbol
sequence SY for decoding the binary values of the bit
positions or, respectively, of bit positions b,i in
that it is not some randomly selected mapping BM which
15   is selected but, instead, for the binary mapping, the
symbols or parameters, respectively, are first sorted
in accordance with their probability and the natural
binary code is allocated to the symbol structure thus
produced.

20   Thus, the natural binary code (NBC) is
allocated to the symbols sorted in accordance with
their probability of occurrence in such a manner that a
code word which has the first binary value at all bit
positions, or a code word which has the second binary
25   value at all bit positions, is allocated to the symbol
occurring most frequently, and a code word which
exhibits the second binary value at all bit positions
or a code word which exhibits the first binary value at
all bit positions is allocated to the symbol occurring
30   most rarely.

This leads to an efficient mapping of the
symbol redundancy to the individual bit position
redundancy; as a result, more redundant information
about the binary values of the individual bit positions
35   b,i can be utilized for error correction. In addition,
more redundant information can be used for decoding the
most significant bit than for decoding the second most
significant bit. The decoding results can be
particularly improved

by a method according to the invention especially for
mapping digital data or vector-quantized parameters to
code words - as is shown by simulation results.

        In the source-controlled channel decoding CD,
5   the residual redundancy (uneven distribution) existing
in the source-encoded symbol sequences SY can then be
utilized more easily and more efficiently since the
redundancy existing at the symbol level is thus
converted into a redundancy (uneven distribution)
10 existing at the bit level which can be used directly by
the source-controlled channel decoder (e.g. Apri-VA).
Using this method, an improved quality can be achieved
in the transmission of the source signals QS (sound,
voice, etc.). The additional computational effort for
15 such sorting before binary mapping BM is low and can be
usually neglected.

        Such binary mapping BM can be implicitly
integrated in the source encoder and decoder. For
codecs which are already standardized such as the GSM
20 full-rate/enhanced full-rate voice codec, however, it
means a modification both in the receiver and in the
transmitter. However, this modification is possible
without any great hardware alteration. In the GSM
system, it is only necessary, in terms of
25 infrastructure, to add the binary mapping and inverse
mapping in the TRAU (transcoder and rate adapter unit),
the BTS (base transceiver station), BSC (base station
controller) etc. remain unchanged.

        Figure 3 shows the frequency distribution of
30 the symbol values c,j and the allocated binary code
words bcw,j. It can be seen here that in the case of
the NBC at the first bit position $b1$, the probability
for the binary value "0" is very much greater than that
for the binary value "1", especially under the
35 condition that symbol $c1$ or $c2$ has been sent. This
information can be utilized in the sense of
a posteriori or a priori information in the source-
controlled channel decoding

in order to decide the binary value of the bit position
b1 or, respectively, to determine the threshold used
for this, and thus to make the decision more reliable.

5   Thus, the decoding can be improved further if
information   on   the   symbol   value c,j probably
transmitted is also used.

If the symbols have not been sorted before the
binary   mapping,   the   a posteriori   or   a priori
information (that is to say the probability for a
10   binary value "0") used in the source-controlled channel
decoding would generally be less and the decoding of
the bit positions could not be carried out so reliably.

In   a   variant   of   the   embodiment   of   the
invention, all or some of the bit positions of code
15   words   are   interchanged   after   sorting   and   mapping
symbols onto code words.

In   an   embodiment   of   the   invention,   the
information consisting of symbol sequences SY is mapped
to   binary   code   words bcw,j having   in   each   case   a
20   plurality of bit positions b,i in such a manner that
even the correlation between the binary values of the
corresponding bit positions b,i,k (or uq,k at frame
level)   and $b,i,k+1$ (or $uq,k+1$ at   frame   level)   of
successive frames k, k+1 is large. In this arrangement,
25   in   particular,   a   correlation   of   the   source   bits   is
taken   into   consideration.   The   basic   concept   of   this
method consists in that corresponding symbols do not
change very often between two successive frames and
there is thus a redundancy in the transmission. This
30   correlation   between   successive   frames   can   be   utilized
especially well at the receiver end, using an APRI SOVA
(a priori soft-output Viterbi algorithm) decoder if a
binary mapping BM is selected in such a manner that the
correlation   between   the   binary   values   of   the
35   corresponding bit positions of the successive frames is
large.

In elaborate

simulations, the use of the GBC as binary mapping has thus been found to be particularly advantageous, especially if the symbols have a Gaussian or an anti-Gaussian distribution which is often the case.

5   In source-controlled channel decoding CD, the inter-frame correlation, that is to say the statistical dependence between temporally and/or spatially adjacent signal samples can also be utilized. To estimate the a priori/a posteriori information, for example, the

10   empirical "HUK algorithm", which is described in "J. Hagenauer, "Source-controlled channel decoding", IEEE Trans. Commun., Vol. 43, pages 2449-2457, Sept. 1995", or a method based on Kalman filters can also be used for source-controlled channel decoding.

15   In a further variant of the embodiment, the information consisting of symbol sequences SY is mapped to binary code words bcw,j having in each case a plurality of bit positions b,i in such a manner that, in the case of a wrongly detected binary value, the

20   error in the detected symbol or, respectively, the output source signal QS is small. By means of a suitable binary mapping BM, the source signals will thus respond less sensitively to co-channel interference. In elaborate simulations, the use of the

25   FBC as binary mapping has thus been found to be particularly advantageous, especially if the symbols have a Gaussian or an anti-Gaussian distribution which is often the case.

Variants of the embodiment are also possible in

30   which the binary mapping BM is selected in such a manner that a number of aspects of the variants described above are combined in the sense of a compromise.

To carry out the method explained above, a

35   program-

controlled signal processor integrated, for example, in
radio equipment, such as a mobile station or base
station of a mobile radio system, is provided which
uses one of the methods described above for coding
5   and/or decoding information to be transmitted.

Patent claims

1.   A method for coding information consisting of
symbol sequences (SY), symbols occurring with different
5   probabilities, in which
       - symbols are mapped to binary code words (bcw,j)
having in each case a plurality of bit positions (b,i)
the mapping taking place in such a manner that
       - the natural binary code (NBC) is allocated to
10 symbols sorted in accordance with their probability of
occurrence.
2.   The method as claimed in claim 1, in which
       - at least an essential proportion of the symbols
or all symbols are sorted in accordance with their
15 probability, and
       - the natural binary code (NBC) is allocated to
at least an essential proportion of symbols sorted in
this manner or to all symbols sorted in this manner or
to all symbols.
20 3.   The method as claimed in one of the preceding
claims, in which the natural binary code (NBC) is
allocated to symbols sorted in accordance with their
probability of occurrence, in such a manner that
       - a code word with exhibits the first binary
25 value at all bit positions or a code word which
exhibits the second binary value at all bit positions
is allocated to the symbol occurring most frequently,
and
       - a code word which exhibits the second binary
30 value at all bit positions or a code word which
exhibits the first binary value at all bit positions is
allocated to the symbol occurring most rarely.
4.   The method as claimed in one of the preceding
claims, in which the symbol sequences (SY) originate
35 from a source encoding (QE).
5.   The method as claimed in one of the preceding
claims, in which

bit positions (b,i) of code words (bcw,j) resulting
from the mapping are interchanged.

6.   The method for decoding information, in which
the information consisting of symbol sequences has been
5   coded in accordance with one of the preceding claims
and the redundant information contained in the symbol
sequences   (SY)   or,   respectively,   the   redundant
information contained in the bit positions of the
associated code words is used as a priori and/or a
10 posteriori information in the determination of the
values of the bit positions (b,i).

7.   A method for transmitting information in which
the information is coded as claimed in one of claims 1
to 5 and decoded as claimed in claim 6.

15 8.   A signal processor comprising means for coding
information as claimed in one of claims 1 to 5.

9.   A   signal   processor   comprising   means   for
decoding information as claimed in claim 6.

10.   Radio equipment containing a signal processor
20 comprising means for coding information as claimed in
one of claims 1 to 5 and means for decoding information
as claimed in claim 6.

GR 98 P 2689

Abstract

Method for coding, decoding and transmitting
information, signal processor and radio equipment

A method for coding information in which the
symbols of information consisting of symbol sequences
are first sorted in accordance with their probability,
then mapped to the natural binary code and thus the
redundant information contained in the symbol sequences
can be used for decoding the bit positions.

Figure 1

Key to figures

Figure 2

5   Rahmen   =   Frame

              Frame

1/3 FIG 1

FIG 2

c_j → bcw,j

b_{j-1} $b_{j,i}$ $b_{j,i+1}$... $b \in 0,1$

SY → BCW

BM

$u_{k-1,q-1}$ $u_{k-1,q}$ $u_{k-1,q+1}$ ... Rahmen k-1 / Frame

$u_{k,q-1}$ $u_{k,q}$ $u_{k,q+1}$ ... Rahmen k / Frame
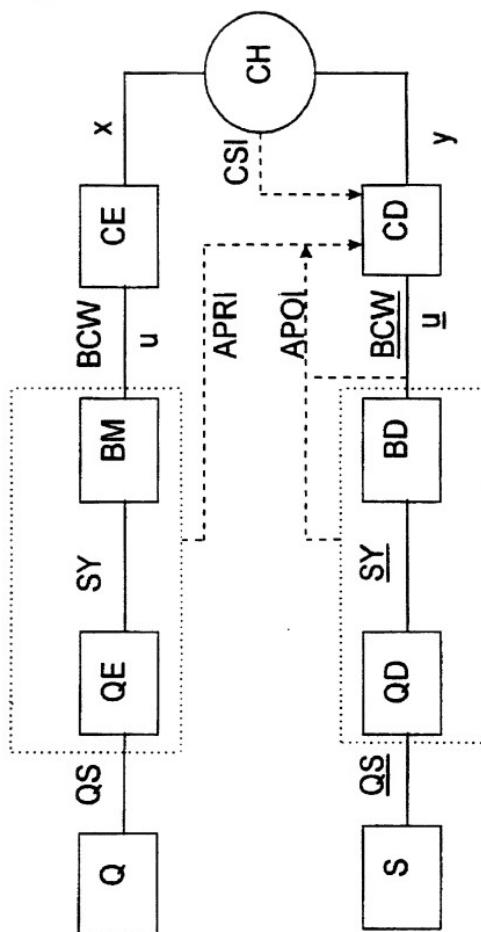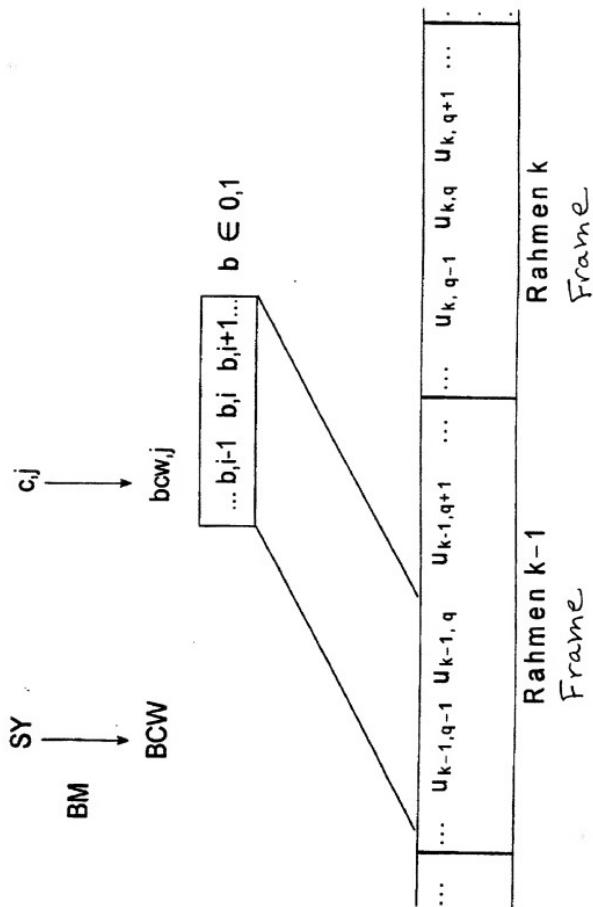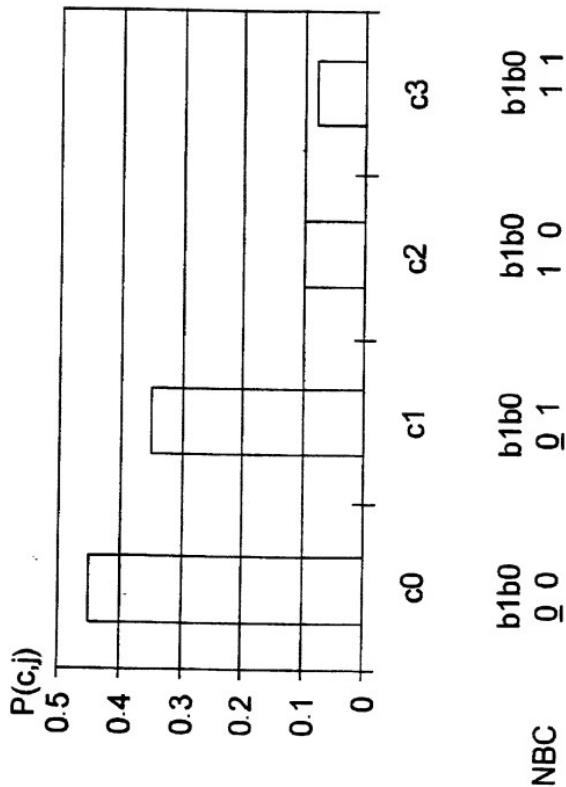
Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:	As a below named inventor, I hereby declare that:
dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,	My residence, post office address and citizenship are as stated below next to my name,
dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:	I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren zur gemeinsamen Quellen- und Kanalcodierung

deren Beschreibung	the specification of which
(zutreffendes ankreuzen)	(check one)
[X] hier beigefügt ist.	[ ] is attached hereto.
[ ] am _____ als PCT internationale Anmeldung PCT Anmeldungsnummer _____ eingereicht wurde und am _____ abgeändert wurde (falls tatsächlich abgeändert).	[ ] was filed on _____ as PCT international application PCT Application No. _____ and was amended on _____ (if applicable)
Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.	I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.
Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.	I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).
Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.	I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

198 43 981.4	Germany	24. September 1998	☒	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein

			☐	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein

			☐	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhangig, aufgegeben)	(Status) (patented, pending, abandoned)

(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

Telefongespräche bitte richten an: *(Name und Telefonnummer)*	Direct Telephone Calls to: *(name and telephone number)* 312/876-0200 Ext. _____

Postanschrift:	Send Correspondence to:. **HILL, STEADMAN & SIMPSON** **A Professional Corporation** **85th Floor Sears Tower, Chicago, Illinois 60606**

Voller Name des einzigen oder ursprünglichen Erfinders	Full name of sole or first inventor:
XU, Wen	
Unterschrift des Erfinders — Datum — 2.2.2001	Inventor's signature — Date
Wohnsitz D-82008 Unterhaching, Germany DE X	Residence
Staatsangehörigkeit ~~Bundesrepublik Deutschland~~ China	Citizenship
Postanschrift Bischofshofener Str. 11 D-82008 Unterhaching Bundesrepublik Deutschland	Post Office Address
Voller Name des zweiten Miterfinders (falls zutreffend).	Full name of second joint inventor, if any:
Unterschrift des Erfinders — Datum	Second Inventor's signature — Date
Wohnsitz	Residence
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address
(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).	*(Supply similar information and signature for third and subsequent joint inventors).*
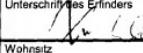
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IN THE UNITED STATES DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II
5   **CHANGE OF ADDRESS OF APPLICANTS' REPRESENTATIVES**

APPLICANT(S):   WEN XU

ATTORNEY DOCKET NO.   P01,0052

INTERNATIONAL APPLICATION NO: PCT/DE99/01993

INTERNATIONAL FILING DATE: July 1, 1999

10   INVENTION: METHOD FOR CODING, DECODING AND
TRANSMITTING INFORMATION, SIGNAL
PROCESSOR AND RADIO EQUIPMENT

Assistant Commissioner for Patents

Washington, D.C. 20231

15   Members of the firm of Hill & Simpson designated on the original

Power of Attorney have merged in the firm of Schiff Hardin & Waite. All

future correspondence for the above-referenced application therefore shoud

be sent to the following address:

Schiff Hardin & Waite
20   Patent Department
6600 Sears Tower
Chicago, IL 60606-6473
CUSTOMER NO. 26574

Respectfully submitted,
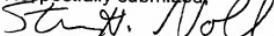
25   Steven H. Noll   (Reg. No. 28,982)
Schiff Hardin & Waite
Patent Department
6600 Sears Tower
30   Chicago, Illinois 60606
Attorneys for Applicant